5.3 GEOLOGIC HAZARDS AND RESOURCES

This section presents information on the general geology of the region, subsurface conditions at the Project Site, the geologic hazards affecting the Project, and the potential effects of the Project on geologic resources. The evaluations of effect significance are based on the type and the proximity of resources to the Project. Recommendations are provided for mitigation of geologic hazards and geotechnical issues at the Project.

The primary geologic sources of published information used for this report include the United States Geological Survey (USGS), the California Geological Survey (CGS) (formerly the California Division of Mines and Geology), and San Bernardino County. Much of the geologic information in this region is based on geologic mapping compiled by Dibblee and Bassett (1966) and the Safety Element of the County of San Bernardino 2007 General Plan (URS 2007a).

Site-specific data was obtained as part of a Preliminary Geotechnical and Geologic Hazards Evaluation performed at the Project site (URS, 2008). That study included geologic mapping and reconnaissance and a review of existing data at the site. A limited geotechnical and geologic investigation was performed on a small portion of the Project by C.H.J. Incorporated (2006).

5.3.1 Project Description

The Project includes the construction, operation, maintenance, and abandonment of up to 850 megawatts (MW) of capacity by a solar power generating facility and its ancillary systems in two phases (Phase I: 500MW [approximately 5,838 acres]/Phase II 350MW [approximately 2,392 acres]). The Project will consist of up to approximately 34,000 SunCatchers. Construction is anticipated to occur over an approximate four-year period beginning in 2010 and ending in 2014. It is estimated that approximately an average of 400 construction and 180 long-term labor jobs will be required.

The Project is located in an undeveloped area of San Bernardino County, California approximately 37 miles east of Barstow, California and north of Interstate 40 (I-40) between approximately 1,925 to 3,050 feet above mean sea level. The Project is located primarily on Bureau of Land Management (BLM) land within the Barstow Field Office. Approval of the Project Right-of-Way (ROW) Grant Application (Form 299, Applications CACA 49539 and 49537) will result in the issuance of a ROW Grant Permit for use of federal lands administered by the BLM. The Project would require a plan amendment to the 1980 California Desert Conservation Area (CDCA) Plan.

The area where the Project would be constructed is primarily open, undeveloped land within the Mojave Desert. The Cady Mountain Wilderness Study Area (WSA) is located north of the Solar One Site. The Pisgah Crater, within the BLM-designated Pisgah ACEC, is located south and east of the Project (south of I-40 by several miles). Several underground and above ground utilities traverse the area as well.

An approved interconnection letter from California Independent Service Operator (CAISO) has been issued for the Project. The associated System Impact Study (SIS) is located in Appendix H. The SIS indicates that additional upgrades to the Southern California Edison (SCE) Lugo-Pisgah No. 2 Transmission Line and upgrades at the SCE Pisgah Substation will be required for the full build out of the 850MW Project. Supplemental studies performed by SCE and CAISO indicate that capacity is available on the existing transmission system to accommodate less than the 850MW Project.

An on-site substation (i.e., Solar One Substation [approximately 3 acres]) will be constructed to deliver the electrical power generated by the Project to the SCE Pisgah Substation. Approximately twelve to fifteen 220kV transmission line structures (90 to 110 feet tall) would be required to make the interconnection from the Solar One Substation to the SCE Pisgah Substation. All of these structures would be constructed within the Project Site.

The Project will include a centrally located Main Services Complex (14.4 acres) that includes three SunCatcher assembly buildings, administrative offices, operations control room, maintenance facilities, and a water treatment complex including a water treatment structure, raw water storage tank, demineralized water storage tank, basins, and potable water tank.

Adjacent to the Main Services Complex, a 14-acre temporary construction laydown area will be developed and an approximately 6-acre construction laydown area will be provided adjacent to the Satellite Services Complex south of the Burlington Northern Santa Fe (BNSF) railroad. Two additional construction laydown areas (26 acres each) one will be located at the south entrance off Hector Road and the other at the east entrance just north of the SCE Pisgah Substation.

Temporary construction site access would be provided off of I-40 beginning east of the SCE Pisgah Substation and would traverse approximately 3.5 miles across the Pisgah ACEC requiring an approximate 30-foot ROW. Long-term permanent access would be provided by a bridge over the BSNF railroad along Hector Road north of I-40. Equipment may be transported during construction via trucks and/or rail car (through the construction of a siding), that would be located on the north side of BNSF railroad and east of Hector Road or as authorized by BNSF.

Water would be provided via a groundwater well located on a portion of the BLM ROW grant north of the Main Services Complex and transported through an underground pipeline. The expected average well water consumption for the Project during construction is approximately 50 acre-feet per year during the construction period. Under normal operation (inclusive of mirror cleaning, dust control, and potable water usage), water required will be approximately 36.2 acre-feet per year. Emergency water may be trucked in from local municipalities.

Earthwork will be kept to a minimum during site preparation, however, earthwork is required to establish grades for building sites, the substation, and paved arterial roads. Paved roadways will be constructed as close to the existing topography as possible, with limited cut and fill operations to maintain roadways at slopes less than 10 percent. Blading for unpaved roadways and foundations will occur between alternating rows of SunCatchers. Minor localized hills or depressions will be removed as needed to provide for proper alignment and operation. Minor cut and fill slopes will be constructed at 2:1 horizontal:vertical (H:V) or flatter. Culverts will be installed in a limited fashion as necessary for crossing of natural washes. In general, cuts and fills on the site will be localized.

5.3.2 Affected Environment

The Project Site is located in the Mojave Desert Geomorphic Province. The Mojave Desert Geomorphic Province is characterized by broad expanses of desert with localized mountains and dry lakebeds. The physiographic province is bounded by the San Bernardino Mountains and the Pinto fault to the south, the San Andreas Fault Zone the west, the Garlock Fault Zone to the north, and the Basin and Range Province to the east.

The following subsections describe the existing geologic and soil conditions, geologic hazards and geologic and mineral resources in the Project area.

5.3.2.1 Geology and Subsurface Conditions

Physiographic Setting

The Project Site is located in the east-central portion of the Mojave Desert Geomorphic Province in an area known as Hector and is shown in Figure 5.3-1. The area is bounded on the north by the Cady Mountains, Sleeping Beauty Peak to the east, Pisgah Crater to the south, and the Lake Manix and Troy Lake basins to the west (Reheis, et. al. 2007). The area is primarily characterized by alluvial zones and washes that gently to moderately slope to the south from the foot of the Cady Mountains. A few small knobs primarily comprised of volcanic rock rise out of the alluvial material at the base of the Cady Mountains. Quaternary-age basalt flows from the Pisgah Crater bound the southern portion of the area. Sediments from one of the high level fluctuations of Lake Manix overlap the western portion of the site to elevations of approximately 1,825 feet mean sea level (msl). Deposits from the Lake Manix basin suggest lake fluctuations that began during the middle Pleistocene and continued though most of the Late Pleistocene (Jefferson 2003).

The topography of the Project ranges in elevation from approximately 2,600 feet msl on the north side down to 1,800 feet msl in elevation in the southwest corner.

Regional Stratigraphy

The stratigraphy of the Mojave Desert region can be divided into two groups according to their inferred age: Pre-Cenozoic rocks (approximately 65 million years ago [mya] and older) and Cenozoic rocks (present to approximately 65 mya). The Pre-Cenozoic rocks represent the basement rocks of the present day Mojave Desert region and are typically represented as mountains and rock outcrops. The Pre-Cenozoic rocks were subsequently overlain by Cenozoic rocks which are typically represented as volcanic mountains and flows, alluvial basins and valleys, and lacustrine lakebed deposits. Detailed descriptions of the two rock groups are provided below.

The Pre-Cenozoic rocks of the Mojave Desert region were generally formed in four phases. The first phase was the formation of metamorphic rocks, mostly gneiss and schist, during the Pre-Cambrian (approximately 543 mya and older). These rocks were formed along with lesser amounts of sedimentary rocks, primarily limestone. The second phase, during the Mesozoic (approximately 65 mya through 245 mya) was a period of volcanic activity and metamorphism resulting in a series of meta-volcanic rocks. The third phase, during the late Mesozoic, was a period in which large magmatic bodies intruded the existing rocks. The cooling of these magmatic bodies resulted in granitic rocks, primarily composed of monzonites and granodiorites (Bassett and Kupfer, 1964). The fourth phase of development of the Pre-Cenozoic rocks consisted of a period of regional metamorphism followed by period of deep erosion.

The Cenozoic rocks of the Mojave Desert region overlay the Pre-Cenozoic rocks. Episodes of volcanic activity throughout the Tertiary (present to approximately 65 mya) resulted in volcanic rock outcrops and mountains throughout the region. Quaternary-age (present to 1.8 mya) volcanoes exist today as basically un-eroded cinder cones and lava fields. Pisgah and Amboy Craters are two present-day examples of such features. Throughout the Tertiary, erosion of the Pre-Cenozoic rocks and more recent volcanic rocks resulted in the development of alluvial filled basins throughout the region. Development of a series of lakes and their subsequent retreat happened primarily in the Pleistocene (0.01 to 1.8 mya) and resulted in lacustrine deposits stratigraphically above the existing Pre-Cenozoic and Cenozoic rocks (Diblee, 1980a).

Local Geology

The geologic units in the Project vicinity are presented in the table below, Geologic Conditions, and are shown on Figures 5.3-3 and 5.3-4, Site Geologic and Mineral Resources Map.

Table 5.3-1
Geologic Conditions

Geologic Map Unit	Unit or Formation Name	Description/Comments
Qa	Quaternary alluvium	Late Pleistocene to Holocene; unconsolidated clay, silt, sand and gravel of alluvial fans and streamwash deposits, partly dissected and poorly sorted. Typically light reddish brown to light brown, Gravelly (~15%), fine to coarse Sand (~85% including eolian deposits), trace Cobbles. Granitic and volcanic clasts up to 8 inches, sub-angular to sub-round and moderately weathered.
Qf	Quaternary alluvial fan gravel	Late Pleistocene to Holocene; unconsolidated silt, sand, gravel and cobbles of slopewash, alluvial fans and streamwash deposits. Typically light reddish brown, Gravelly (~30%), coarse to fine Sand (~50%), with Cobbles (~20%). Granitic and volcanic clasts up to 18 inches, sub-angular to sub-round and moderately weathered.
Qb	Quaternary basalt of Pisgah flow	Holocene; dark gray Basalt, vesicular, moderately weathered and strong. Recent flows from nearby Pisgah Crater.
Qlc	Quaternary lacustrine deposits	Late Pleistocene to Holocene lake deposits; fine-grained dry lake bed deposits displaying mud cracks in localized surface depressions and in the low lying areas.
Qoa	Quaternary older alluvium	Pleistocene; moderately dissected, moderately consolidated, poorly sorted clay, silt, sand and gravel of older alluvial fans, terraces, and channel deposits. Typically light reddish brown to light brown, Gravelly (~15%), fine to coarse Sand (~85%), trace Cobbles. Granitic and volcanic clasts up to 8", sub-angular to sub-round and moderately weathered.
Qof	Quaternary older fanglomerate and gravel	Pleistocene; partly dissected, largely unconsolidated silt, sand and gravel deposits of slopewash, older alluvial fans and terraces. Typically light reddish brown to light brown Sandy Gravel/Gravelly Sand with few Cobbles. Predominantly volcanic clasts up to 15 inches, sub-angular to sub-round and moderately weathered.

Table 5.3-1
Geologic Conditions

Geologic Map Unit	Unit or Formation Name	Description/Comments
Tb	Oligocene or Miocene basalt	Oligocene or Miocene; inselberg forming volcanics, gray to dark gray, porphyritic, moderately vesicular, moderately weathered, strong.
Ta	Oligocene or Miocene andesite	Oligocene or Miocene; inselberg forming volcanics, light gray to gray, porphyritic, moderately weathered, strong.
Tab	Oligocene or Miocene andesitic breccia	Oligocene or Miocene; inselberg forming volcanics, light gray to gray, moderately weathered, strong. Flows and flow breccia composed predominantly of aphyric to porphyritic andesite.
Gqm	Mesozoic granite to quartz monzonite	Mesozoic; reddish brown to light brown, mountain forming, coarse-grained, subequigranular, moderately weathered, evident spheroidal weathering.

The Project Site is near the toe of an alluvial fan emanating from the Cady Mountains located north-northeast of the site. Geologic mapping of the site and surrounding areas show the site underlain by young alluvial fan deposits of Holocene (present to 0.01 mya) to late Pliestocene age. The alluvial deposits are overlain in part by Holocene basalt of the Pisgah flow (C.H.J. Incorporated 2006). A number of Oligocene or Miocene basaltic and andesitic volcanic rock outcrops were mapped in the northeastern portion of the Project site

Younger late Pliestocene and Holocene-age alluvial deposits dominate the Project site, as shown on Figure 5.3-3. The preliminary geotechnical investigation for the demonstration site (C.H.J. Incorporated 2006, included in Appendix E) included the advancement of four exploratory borings. Those explorations encountered near-surface deposits composed primarily of loose eolian dune sands underlain by dense to very dense alluvial soils. The alluvial soils encountered consisted of poorly graded sand and silty sand, both with gravel. Localized gravelly lenses were encountered within the borings. Drill rig refusal, attributed to nested cobble or boulder sized clasts, occurred in two of the borings at depths of 29 and 46 feet.

To a lesser degree, lacustrine deposits were mapped along the southwestern portion. In general, these Pleistocene dry lake bed deposits consist of interbedded fine-grained sand, silts and clays displaying mud cracks in localized surface depressions and in the low lying areas.

The Pisgah lava flows, which are mapped on the southwestern and southeastern edge of the Project site, originated from the Pisgah Crater and are quite extensive. They are believed to be late Quaternary-age to have been representative of the last activity of the region.

Tectonic Framework

The Mojave Desert Geomorphic Province is a wedge shaped area largely bounded by the San Andreas Fault Zone and the Garlock Fault and is structurally referred to as the Mojave Block. The Mojave Block is cut by a series of northwest to southeast striking faults as shown on Figure 5.3-4. Collectively, the strike slip faults in the Mojave Block are referred to as the Eastern California Shear Zone (ECSZ). The epicenters of historical earthquakes experienced in southern California are also shown in Figure 5.3-4.

Faults and Seismicity

Significant faults within 62 miles (100 kilometers) of the Project site are provided in Table 5.3-2 below. The faults are listed in order of proximity to the center of the Project site. Fault type, fault length, maximum estimated slip rate, and probable maximum earthquake magnitude are also listed in the table.

Table 5.3-2
Significant Faults within 62 Miles (100 Kilometers) of Project Site

Fault Name	Nearest Distance to Solar One Site miles (km)	Type of Faulting[1]	Fault Length[1] miles (km)	Maximum Estimated Slip Rate inches/year (mm/year)[1]	Probable Maximum Earthquake Magnitude[1] (M_{max})
Lavic Lake	0	right-lateral strike-slip	17 (27)	Unknown	7.1
Pisgah	0	right-lateral strike-slip	21 (34)	0.04 (0.8)	6.0 – 7.0
Calico	14.0 (22.5)	right-lateral strike-slip	21 (95)	0.10 (2.6)	7.1
Camp Rock	20.0 (32.2)	right-lateral strike-slip	22 (35)	0.04 (1.0)	6.8
Lenwood	28.0 (45.1)	right-lateral strike-slip	22 (35)	0.03 (0.8)	6.8
North Frontal Zone	35.0 (56.3)	thrust	40 (65)	0.04 (1.0)	7.1
Helendale	44.0 (70.1)	right-lateral strike-slip	31 (50)	0.03 (0.8)	7.3
Gravel Hills	45.0 (72.4)	right-lateral strike-slip	31 (50)	0.04 (0.9)	7.2
Pinto Mountain	46.0 (74.0)	left-lateral strike-slip	45 (30)	0.04 (1.0)	7.5
Garlock	53.0 (85.3)	left-lateral strike-slip	155.0 (250)	0.43 (11)	7.1
Death Valley	54.0 (86.9)	right-lateral strike-slip	71 (115)	0.12 (3.0)	7.3
San Andreas	56.0 (90.1)	right-lateral strike-slip	745 (1,200)	1.41 (36)	7.9
Cleghorn	58.0 (93.3)	left-lateral strike-slip	19 (30)	0.10 (3.0)	Unknown

Notes:
1. Data obtained from the Southern California Earthquake Center (SCEC) website. See references.

Primary seismic sources and earthquake epicenters (greater than Magnitude 3) are shown on Figure 5.3-4, Regional Fault and Historical Epicenters Map. The following sections discuss significant faults in order of increasing distance.

Eastern California Shear Zone (ECSZ)

Geodetic studies have suggested that approximately 6 to 8 millimeters per year (mm/yr) of right-lateral slip are accommodated across the ECSZ (Sauber et al. 1986). This movement represents approximately 15% of the motion between the Pacific and North American plates. Individual faults within the ECSZ have estimated slip rates of less than 1 mm/yr. These are relatively low slip rates when compared to the San Andreas fault (36 mm/yr) or the major faults west of the San Andreas in southern California that include the San Jacinto (12 mm/yr), Elsinore (6 mm/yr), Palos Verde (3 mm/yr) and Newport-Inglewood faults (1.5 mm/yr). Given the relatively low slip rates of the faults in the ECSZ, the recurrence interval between moderate to large earthquakes on any of the these faults is relatively long, on the order of 5,000 years or longer.

Despite the long recurrence intervals estimated for moderate or large earthquakes on individual faults within the ECSZ, there have been two significant earthquakes in the region within the last 15 years. The 1992 Landers event ruptured along a series of faults in the central portion of the ECSZ, about 45 miles south of the Project site. This Moment Magnitude (M_w) 7.3 event was accompanied by significant ground rupture, with over 18 feet of slip noted at certain locations, and over 3 feet of slip noted over 53 miles of the rupture.

In 1999, less than 7 years later, a M_w 7.1 event occurred on the Bullion and Lavic Lake faults (referred to as the Hector Mine Earthquake). These events were located approximately 18 miles to the south of the Project Area. The overall length of ground rupture has been estimated at 28 miles with significant slip (greater than an inch or so) occurring over a distance of about 22 miles. Maximum displacement was estimated at 17 feet of right slip and an average slip of approximately 8 to 10 feet.

Pisgah-Bullion and Lavic Lake Fault Zones

Two faults within Earthquake Fault Zones (Alquist Priolo Zones) are mapped on the Project Site as seen in Figure 5.3-2. The westernmost is the Pisgah fault and is considered part of the Pisgah-Bullion fault zone. The northern portion of the Bullion Fault is presumed to connect in the subsurface with the Pisgah Fault (Hart 1987). This fault zone is a right-lateral fault system and is considered by the state of California to have a maximum M_w of 7.1 as evidenced by the Hector Mine Earthquake of 1999.

The second Earthquake Fault Zone projecting into the site is the northern extension of the Lavic Lake Fault Zone. It extends northwest from near the center of the Pisgah-Bullion Fault Zone. It runs just east and parallel to the Pisgah-Bullion Fault Zone. Due to limited surface expression and young alluvial cover the northernmost part of this fault zone was simply mapped as “Fault A and Fault B” (Hart 1987).

Shaking along these faults during the Hector Mine Earthquake of 1999 is interpreted as producing as much as 510 mm in horizontal motion near the epicenter. However, northward, towards the Project Site, this movement diminishes to as little as 2 mm of movement. No movement was recorded north of I- 40 or in the Project area during this event.

Recent observations of the Pisgah and Lavic Lake faults were made with stereo ortho-photographs and field reconnaissance mapping. Mapped interpretations of these fault projections can be seen in Figure 5 of URS (2008) which is included as Appendix E.

Cady Fault and Unnamed Faults in the Cady Mountains

The Cady fault is an east-west trending fault that exists approximately 9 miles north of the site in the northern flank of the Cady Mountains and runs for approximately 12 miles. It is a left-lateral, strike-slip fault. It is believed to have ruptured in the Quaternary and movement is shown in older alluvial deposits. However, younger alluvium overlays the eastern end of the fault which suggests no recent movement.

Two northeast trending faults that exist in the igneous rocks north and northeast of the project site are likely pre-Quaterary in age and recent faulting is not likely. The easternmost of these faults runs from the northeast corner of the Project site parallel to the existing transmission line to the northeast. The other fault runs northeast into the Cady Mountains from just north of the northwest corner of the Project Site (Figure 5.3-3).

Calico Fault

The Calico Fault is a northwest-southeast trending right lateral, strike-slip fault that exists approximately 14 miles to the east of Project Site. It has an estimated horizontal slip rate of 0.10 inches a year with a probable maximum M_w of 7.1. It is estimated to rupture every 1,500 years with the most recent rupture being March 18, 1997.

Camp Rock and Ludlow Faults

As is characteristic of major faults within the ECSZ, the Camp Rock and Ludlow Faults trend northwest-southeast and display right-lateral, strike-slip displacement. These faults are mapped to extend within 20 miles west and 12 miles east, respectively, of the Project site. The Camp Rock, Emerson, and Copper Mountain faults make up a roughly continuous fault system some 62 miles in length. About 12 miles of the Camp Rock fault ruptured in the Landers earthquake of 1992. The State assigns a maximum M_w 7.3 to the Camp Rock-Emerson Fault (Cao et al. 2003). The State does not consider the Ludlow fault in recent hazard assessments.

Pinto Mountain Fault

The Pinto Mountain Fault forms the south-central boundary of the Mojave Desert block, truncating several of the northwest-trending faults characteristic to this region. The Pinto Mountain Fault is a left-lateral, strike-slip fault which has a significant vertical component of displacement (down-to-the-south) particularly in the western sections (Bryant 1986). This fault is located 46 miles south of the Project Site and was assigned a maximum M_w of 7.0 by the State seismic hazard assessment (Cao et. al. 2003).

Garlock Fault Zone

The Garlock Fault zone marks the northern boundary of the Mojave Block and is one of the most obvious geologic features in southern California. It is a left-lateral strike-slip fault that connects at an acute angle to the San Andreas Fault Zone and trends northeasterly to its terminus in the northern Mojave Desert. The slip rate ranges from 2 to 11 millimeters per year, with a rupture interval ranging between 200 and 3000 years. The Garlock Fault Zone is given a probable maximum M_w 7.6. The most recent earthquake with a M_w of 5.7 was on July 11, 1992 near the town of Mojave.

San Andreas Fault Zone

The San Andreas Fault extends northwest through California from the Salton Sea to Cape Mendicino, following a major zone of right-lateral crustal interaction between the Pacific and North American lithospheric plates. Mapped traces of the fault along the southwestern edge of the Mojave Desert block are located approximately 56 miles to the southwest of the project site. The State seismic hazard model (Cao et. al., 2003) assigned a M_w 7.5 to the nearest portions of the San Andreas Fault.

5.3.2.2 Geologic Hazards

The primary geologic hazards at the Project Site and associated linears include strong ground motion from a nearby seismic event or fault rupture on one of the two active faults that cross the site. Evaluations of ground surface rupture, seismic shaking, mass wasting and slope stability, liquefaction, volcanic hazards, subsidence, tsunami runup, flooding, and expansion or collapse of soil at the site are discussed below.

Surface Rupture

In 1972 the State of California passed the Alquist-Priolo Earthquake Fault Zoning Act to mitigate the hazard of surface faulting to structures for human occupancy. The main purpose of the Act is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. There are two mapped Earthquake Fault Zones that encroach upon the project site as shown on Figure 5.3-2. The western-most fault is the Pisgah Fault and the south-central one is the northern end of the Lavic Lake Fault.

The potential for surface rupture of strands of the Pigah and Lavic Lake faults across the Project Site is moderate. Design-level geotechnical studies should address these potential hazards.

Seismic Shaking

The site lies in the Eastern California Shear Zone, an area of moderate to high seismicity and numerous active faults. Moderate to high levels of ground shaking could occur at the site as a result of an earthquake on any of a number of faults in the region, including the San Andreas, Garlock, Camp Rock-Emerson, Pinto Mountain, and other active faults shown in Table 5.3.2. The Project is likely to be affected by an earthquake on one of these faults during its life.

To provide an estimate of the ground motions expected at the site, a Probabilistic Seismic Hazards Analysis (PSHA) will be performed as part of final design studies for the Project. The PSHA incorporates the contribution of all known active faults near the site for which published data are available. The analysis attempts to account for uncertainty in rupture size, rupture location, magnitude, and frequency, as well as uncertainty in the attenuation relationship. According to estimates by the California Geological Survey in 2002, the preliminary peak ground acceleration (PGA) with a probability of 10 percent exceedance in 50 years (return period of 475 years) is 0.20g (units of gravity) to 0.40g for the site (CGS, 2008).

Liquefaction

Liquefaction is a process in which saturated soils lose strength because of earthquakes or other sources of ground shaking. The soil deposit temporarily behaves as a viscous fluid; pore pressures rise, and the strength of the deposit is greatly diminished. Liquefaction is often accompanied by sand boils, lateral spreading, and post-liquefaction settlement as the pore pressures dissipate. Liquefiable soils typically consist of saturated, cohesionless sands and silts that are loose to medium dense. Liquefaction is not typically thought to occur if groundwater is deeper than 50 feet below the ground surface.

The potential for liquefaction at the site was evaluated as part of the preliminary geologic and geotechnical evaluation for the Project (URS 2008). Loose granular materials may be present near the ground surface; however, groundwater is on the order of 300 feet below the ground surface. The depth to groundwater was measured at 310 feet below the ground surface during a pumping test performed on a well located on the southern portion of Section 1 (T8N-R5E) during October 2008 (SES 2008). Due to the depth to groundwater, the potential for liquefaction to occur at the site is low. Further, the Geologic Hazard Overlay in the San Bernardino County General Plan (URS 2007a) does not classify the site area as having a potential for liquefaction.

Subsidence and Collapse

The Mojave River area is subjected to subsidence from fluid withdrawal (generally associated with groundwater wells). Minor subsidence has been detected as close to the proposed Project as the Troy Lake area. The majority of the Project Site is outside of the areas being monitored for subsidence within the Mojave River groundwater basin. The potential for damaging localized differential settlement from subsidence is considered low, given the limited groundwater lowering within the Project site. Further, the planned facilities are not highly sensitive to small magnitudes of settlement. While an increase in groundwater withdrawal is expected to occur as part of the Project, the impact to regional groundwater levels and subsidence is expected to be limited. (Stamos, et al. 2004; Sneed et al. 2003).

Loosely deposited alluvium and colluvium can be subject to collapse due to wetting and/or inundation. The only areas of the site subject to significant saturation are within the washes. These areas have been inundated in the past, and are not likely to experience additional collapse settlement. Natural drainage patterns are not significantly changed as part of the Project and the existing washes are excluded from development areas. Therefore, the Project should not increase the potential for collapse settlement to occur at the site and the potential for collapse settlement to affect the Project is low.

Expansion Potential

Expansive soil and rock shrink and swell with changes in moisture content. Near-surface alluvial deposits on the Project site are expected to consist of primarily sand and gravel with a low expansion potential. Cohesive soil was not encountered in the borings advanced for the demonstration site (C.H.J. Incorporated 2006). Some lacustrine soils were observed in the southwest portion of the site (see Figure 5 in Appendix E). Visual observations indicated the soil has a high silt content, however, a potential exists for expansive material to be present. The likelihood for expansive soil to impact the Project is judged to be low over the majority of the site and low to moderate in the southwest corner of the site.

Flooding

The Project is approximately five miles south of the Mojave River, which is the nearest body of water. The site is mapped outside of the area classified as the limits of inundation due to a dam failure on the Hazard Overlay in the San Bernardino County General Plan (URS 2007a). Further, the site is not mapped within a Flood Plain Safety Overlay District by FEMA (URS 2007a). Therefore, it is very unlikely that flooding will affect the Project. Flooding can also occur due to significant rainfall events, although the effect will likely be limited to flows within the washes. These hazards are discussed further below.

Surface Water

The Project is crossed by a series of active alluvial washes. Extensive gullies and channels are present across the Project Site and throughout the general area. Surface water flow across the Project Site is likely to occur during periods of intense rainfall. The majority of the flow should be confined to the existing washes at the site, provided natural drainage patterns are maintained.

Tsunamis

The Project Site is on the order of 2,000 feet above mean sea level, and therefore the potential for flooding at the Project as a result of a tsunami is considered to be very low.

Seiches

A wave created by earthquake shaking in an enclosed body of water is called a seiche. The potential for a seiche to occur is related to the natural frequency of vibration of the body of water, as well as the predominate frequencies of vibration in the seismic event. There are no significant bodies of water in the site vicinity. Therefore, the potential for flooding at the site as a result of a seiche is considered to be very low.

Landslides (Mass Wasting and Slope Stability)

Landslides can occur due to the presence of steep slopes, saturated soil or rock, and/or seismic activity. The majority of the site is on relatively level or gently sloping ground; therefore, the risk of land sliding is very low. The mountains on the north boundary have a low to moderate potential for landslide activity, based on preliminary observations. The Geologic Hazard Overlay in the San Bernardino County General Plan (URS 2007a) does not map the site within an area of landslide susceptibility. Based on the available information, the potential for landslides to affect the Project is low.

Volcanic Hazards

The Safety Element of the San Bernardino County General Plan (URS 2007a) comments on the volcanic centers around the county. While volcanic eruptions have not occurred within approximately the last 6,000 years, the volcanic areas are considered dormant rather than extinct. The County Safety Element considers the potential for volcanic eruptions to be remote.

5.3.2.3 Geologic Resources

Based on published data (USGS 2008) and site observations (URS 2008), two mining operations are present within the Project boundaries and several others are within two miles of the Project limits. These locations are shown in Figure 5.3-2. One mining operation was close to the site boundary northwest of the intersection of I-40 and Hector Road. Talc/soapstone had been mined in this location but the mine is currently inactive (USGS 2008). Another mine processing operation was present on-site near the northeast site boundary. This abandoned processing and loading facility probably supported the Logan and Read Ridge mines located to the northeast of the site.

The small-scale state and commercial operations outside of the Project limits have mined both metals (manganese, lead, and copper) and non-metallic minerals (bentonite, boron-borates, clay, pumice, sand, and gravel). Manganese mines (abandoned) dominate the mountains to the northwest of the site and include the Logan, Read Ridge, Big Reef/Black Butte. These mines are shown on Figure 5.3-2. An abandoned pumice mine is present near the transmission line on the east side of the site. (USGS 2008)

The only mine reported to be active in the site vicinity is a small-scale aggregate operation approximately 2 miles west of the site along I-40 (USGS 2008). A larger aggregate mining operation is present approximately 14 miles west of the site along I-40. It was reported that in 2005 this aggregate mining operation produced less than 0.5 million tons per year (Kohler 2006).

CGS information indicates there are no active gold mines on the Project Site (CGS 2008). Some historic lode gold mines are present in the project vicinity in the mountains to the north and east of the site (Youngs 1998).

Due to the limited presence of geologic resources on the site, and the relative distance of significant resources from the site, the Project does not represent a significant effect to the geologic resources of the region.

5.3.3 Environmental Consequences

Potential effects of the Project on the geologic or mineral resources and potential effects of geologic hazards on the Project can be divided into those related to construction activities and those related to Project operation.

5.3.3.1 Construction-Related Effects

Construction-related effects to the geologic or mineral resources primarily involve grading operations. The proposed improvements include minor excavation and grading for building and equipment pads and foundations, utility trenches, and roads. Site grades will be maintained as close to existing topography as possible; cuts and fills are expected to be minor. Grading operations will be designed to balance cut-and-fill areas such that no significant importation or stockpiling of fill will take place. Minor grading may also be performed within the laydown area. Temporary slopes will be constructed at stable inclinations.

Potentially significant effects by geologic conditions during construction of the Project are not anticipated. Further, site development is not anticipated to result in significant adverse effects to geologic resources. With implementation of the mitigation measures outlined in Section 5.3.5, Mitigation Measures, effects of construction on the geologic environment will be reduced to less-than-significant levels.

5.3.3.2 Operation-Related Effects

No significant effects to geologic hazards or resources have been identified as a result of operation and maintenance. Potential effects of geologic hazards on the operation of the Project include seismic shaking and fault rupture. With implementation of the measures outlined in Section 5.3.5, Mitigation Measures, effects to Project operations and maintenance from geologic hazards will be reduced to a less than a significant level.

5.3.4 Cumulative Effects

Cumulative effects to the geologic resources at the Project Site are considered to be negligible.

5.3.5 Mitigation Measures

5.3.5.1 Fault Rupture

There is a potential for surface rupture of strands of the Pigah and Lavic Lake faults that cross the Project site. Additional evaluation of the fault strands will be performed during design-level geotechnical studies to confirm the activity level of on-site faults. To verify that active faults do not cross the footprints of proposed habitable structures, fault trenching investigations will be performed. In addition, setbacks will be established from the active faults so that no occupied structure will be located on or near active faults. Linear elements that cross active faults will incorporate mitigations to reduce fault rupture hazard to less than significant. With implementation of the following mitigation measure, it is expected that the potential for fault rupture to affect the Project can be reduced to less-than-significant levels.

GEO-1

Conduct fault and geologic hazard studies as part of final design for the Project. Studies will include excavating fault trenches across identified strands of the Pisgah or Lavic Lake faults that have the potential to project toward occupied structures. The study will be performed by a State-Certified Engineering Geologist.

5.3.5.2 Seismic Shaking

The potential exists for strong ground shaking from a variety of nearby sources, including the San Andreas, Garlock, Camp Rock-Emerson, Pinto Mountain, and other significant faults listed in Table 5.3-2. With implementation of the mitigation measures noted below, it is expected that the potential for seismic shaking to affect the Project can be reduced to less-than-significant levels.

GEO-2

Project facilities will be designed in accordance with the applicable building codes' seismic design criteria. Seismic design criteria in accordance with the 2007 California Building Code (CBC) are provided in Appendix E, Preliminary Geotechnical and Geologic Hazards Evaluation. The dish structures, and possibly other structures at the site, will be designed to resist the seismic loading developed as part of the PSHA.

5.3.5.3 Liquefaction

No liquefaction hazard exists at the Project Site and no mitigations are suggested.

5.3.5.4 Subsidence

The potential for subsidence and/or collapse to affect the Project is low and no mitigations are suggested.

5.3.5.5 Expansive Soils

Expansive soils are not expected to be present over the majority of the site, however some potential exists within the lacustrine deposits in the southwest corner of the site (Figure 5, Appendix E). This will be further evaluated as part of a final geotechnical investigation. Should it be encountered, expansive soil is not likely to impact design of the SunCatcher foundations. Structures requiring shallow foundations are not planned in the area of the lacustrine deposits. The potential for expansive soils to affect the Project is low and no mitigations are suggested.

GEO-3

Perform design level geotechnical studies for the proposed Project. The study will be performed by a registered Geotechnical Engineer and the results will be presented in a written report. Should expansive soil be encountered, geotechnical recommendations will be presented to mitigate any impacts on the project.

5.3.5.6 Flooding

The larger washes within the Project Site may be subject to significant flow during periods of high rainfall; however, no significant development is planned within these washes. Site development and grading will be performed in a manner that will reduce the effects of drainage and runoff across the Project Site to less-than-significant levels, as discussed in Section 5.3.5.8, Site Grading.

5.3.5.7 Landslides

Significant landslide hazards are not present in the Project Area.

5.3.5.8 Site Grading

Due to the expected volume of earthwork, a grading permit is required before commencing site work. Construction activities would also be performed in accordance with the soil erosion/water quality protection measures to be specified in the Construction Storm Water Pollution Prevention Plan (SWPPP) for the Project. The SWPPP is discussed further in Section 5.5, Water Resources. In addition, mitigation measures will be implemented to reduce potentially significant erosion-related effects to the soils resources at the Project Site to insignificant levels. These mitigation measures are discussed in Section 5.4, Soils. With implementation of the soil erosion/water quality protection measures and mitigation measures referenced above, no significant effects are anticipated because of Project construction and operation.

As part of the above-referenced measures, Low Impact Development (LID) will be used to mitigate the potential for water and wind erosion of the soil at the site. LID principles applicable to this Project include:

- maintaining natural drainage and landscape features to slow and filter runoff and maximize groundwater recharge,
- minimizing new impervious ground surfaces, and
- managing runoff close to the source.

Best Management Practices contained in the SWPPP, as discussed Section 5.5, Water Resources, will be implemented to address LID concerns. Further, site grading will be minimized for roads, the Main Services Complex and the substation by constructing as close to the existing topography as possible. Polymeric stabilizers may be used to reduce the amount of imported soil needed for roadway construction and to reduce the need for dust control. Retention basins, infiltration swales, and perforated risers (which act as a desilter) are also planned as part of the Project.

5.3.5.9 Geologic Resources

No significant effects to geologic resources would occur; therefore, no mitigation is recommended.

5.3.6 Compliance with LORS

The Project will be constructed and operated in accordance with all laws, ordinances, regulations, and standards (LORS) applicable to geologic hazards and resources discussed below and summarized in Table 5.3-3, Summary of LORS – Geologic Hazards and Resources.

Table 5.3-3
Summary of LORS – Geologic Hazards and Resources

LORS	Requirements	Conformance Section	Administering Agency	Agency Contact
Federal Jurisdiction				
No federal LORS are applicable				
State Jurisdiction				
Public Resources Code 25523(a), Alquist-Priolo Earthquake Fault Zone	Habitable structures must avoid active fault rupture hazards	Section 5.3.5.2	California Energy Commission	1
Local Jurisdiction				
California Building Code, Chapters 16, 18, and 33	Codes address excavation, grading and earthwork construction, including construction applicable to earthquake safety and seismic activity.	Section 5.3.3 and Appendix E, Preliminary Geotechnical and Geologic Hazards Evaluation	County of San Bernardino Land Use Services Department, Building & Safety Division	2
San Bernardino County Development Code, Chapter 82.15 Geologic Hazard (GH) Overlay	In Geologic Hazard Overlay areas where the construction of roads or structures is planned, a detailed geologic study shall be prepared. Utility lines and streets shall be perpendicular to fault crossings, unless approved otherwise.	Section 5.3.3	County of San Bernardino Land Use Services Department, Building & Safety Division	2
County of San Bernardino 2007 General Plan, Section VIII – Safety Element				
Goal S 6	The County will protect residents from natural and manmade hazards.	Section 5.3.3	County of San Bernardino Land Use Services Department, Building & Safety Division	2
Policy S 6.1	Require development on hillsides to be sited such that the extent of topographic alteration is minimized.	Section 5.3.3	County of San Bernardino Land Use Services Department, Building & Safety Division	2
Goal S 7	The County will minimize exposure to hazards and structural damage from geologic and seismic conditions.	Section 5.3.3	County of San Bernardino Land Use Services Department, Building & Safety Division	2
Policy S 7.1, Program 2	Sites shall be developed in accordance with geotechnical/geologic reports and associated recommendations.	Section 5.3.3	County of San Bernardino Land Use Services Department, Building & Safety Division	2

Table 5.3-3
Summary of LORS – Geologic Hazards and Resources

LORS	Requirements	Conformance Section	Administering Agency	Agency Contact
Policy S 7.1, Program 4	Facilities shall meet specifications of the County Geologist.	Section 5.3.3	County of San Bernardino Land Use Services Department, Building & Safety Division	2
Policy S 7.1, Program 5	The County can require site-specific geotechnical analysis for development adjacent to potentially active faults.	Section 5.3.3	County of San Bernardino Land Use Services Department, Building & Safety Division	2
Policy S 7.3	Coordinate with local, regional, state, federal and other agencies regarding seismic hazards.	Section 5.3.3	County of San Bernardino Land Use Services Department, Building & Safety Division	2
Policy S 7.4	Designate areas and meet requirements of the Alquist-Priolo Earthquake Fault Zoning Act.	Section 5.3.3	County of San Bernardino Land Use Services Department, Building & Safety Division	2

5.3.6.1 Federal

No federal LORS exist for geological hazards and resources, or grading and erosion control.

5.3.6.2 State

California Public Resources Code 25523(a): 20 California Code of Regulations Section 1252 (b) and (c)

None of the habitable Project components will be located on or in proximity to active faults. Based on design-level studies, setbacks will be established from active faults for all habitable structures. These setback recommendations will be prepared in conformance with the Earthquake Fault Hazard Zoning Act.

California Environmental Quality Act (CEQA)

The California Energy Commission will be the lead agency for rules and regulations to implement CEQA. CEQA Guidelines, Appendix G, Section VI contains the geologic hazards and resources related to the Project.

5.3.6.3 Local

California Building Code

The 2007 edition of the CBC is based on the 2006 edition of the International Building Code, with revisions specifically tailored to geologic hazards in California.

Chapter 16: Structural Design

This chapter requires structural designs to be based on geologic information for seismic parameters, soil characteristics, and site geology.

Chapter 18: Soils and Foundations

This chapter sets requirements for excavations and fills, foundations, and retaining structures with regard to expansive soils, subgrade bearing capacity, seismic parameters, and also addresses waterproofing and damp-proofing foundations. In Seismic Zones 3 and 4, as defined by the CBC, liquefaction potential at the site should be evaluated.

Chapter 33: Site Work, Demolition and Construction, and Appendix Chapter 33

This chapter and appendix establish rules and regulations for construction of cut-and-fill slopes, fill placement for structural support, and slope setbacks for foundations.

County of San Bernardino 2007 General Plan, Section VIII – Safety Element

The Safety Element of the County of San Bernardino General Plan provides an implementation program to reduce the threat of seismic and public safety hazards within San Bernardino County. The safety element addresses geologic issues including development on slopes, seismic design, and active faults, and includes requirements for geotechnical and geologic studies. It also requires compliance with regulations of other agencies and the California Building Code.

The Project would comply with the Safety Element of the County of San Bernardino General Plan. The County will review the geologic information and geotechnical recommendations presented in the geotechnical report.

5.3.6.4 Agencies and Agency Contacts

Agencies with jurisdiction to enforce LORS related to geologic hazards and resources, and the appropriate contact person are summarized in Table 5.3-4, Agency Contact List for LORS.

Table 5.3-4
Agency Contact List for LORS

No.	Agency	Contact	Address	Telephone
1	California Energy Commission Facilities Siting Division	Eileen Allen, Energy Facility Licensing Program	1516 Ninth Street, MS-15 Sacramento, CA 95814	916-654-4082
2	County of San Bernardino Land Use Services Department, Building & Safety Division	Lynn Davis	15456 W. Sage Street Victorville, CA 92392	760-241-7691

5.3.6.5 Permits Required and Permitting Schedule

The permits required for this Project are listed in Table 5.3-5, Applicable Permits. A Grading Permit will be required before construction.

Table 5.3-5
Applicable Permits

Responsible Agency	Permit/Approval	Schedule
County of San Bernardino Land Use Services Department, Building & Safety Division	Grading Permit	Before construction

5.3.7 References

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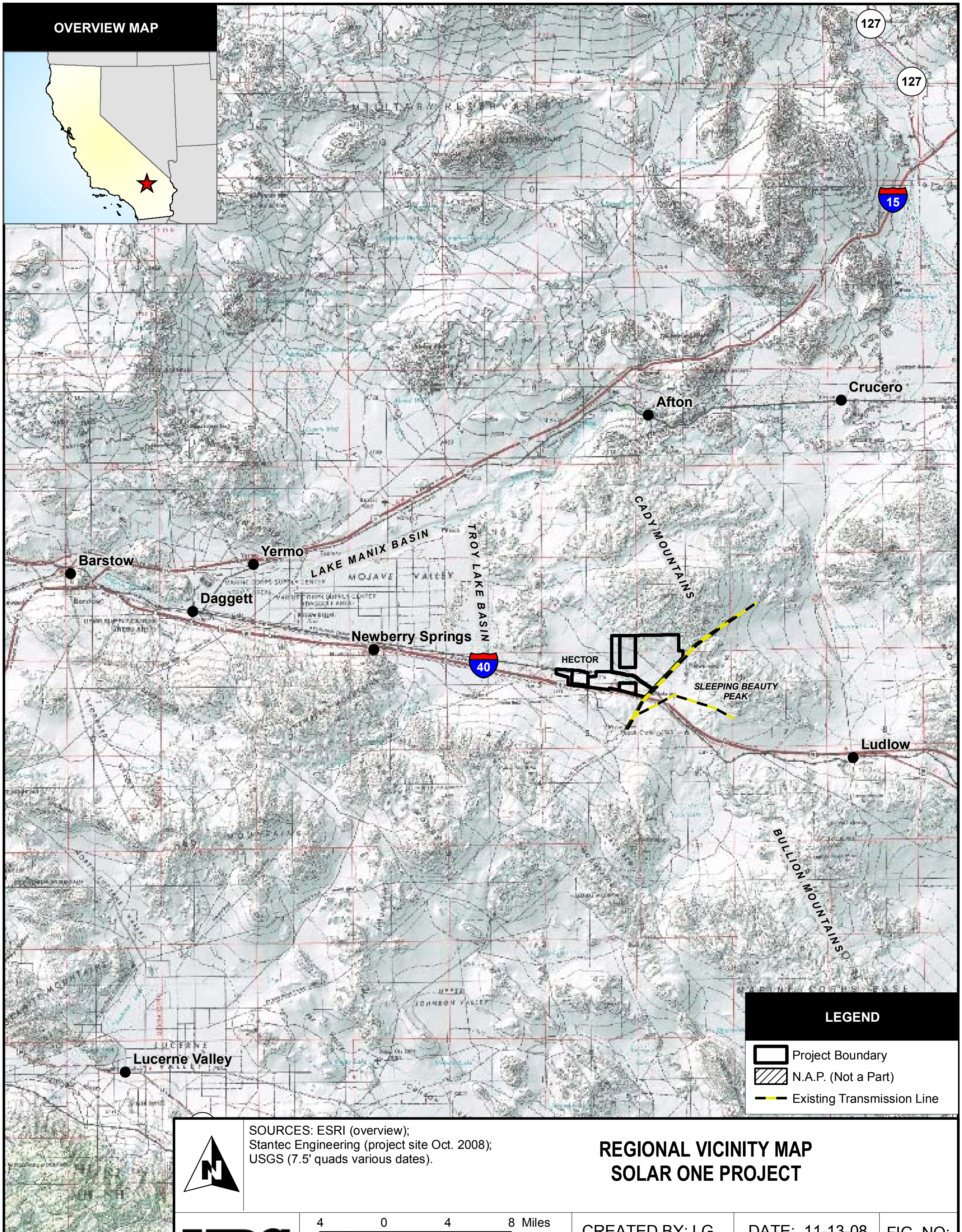
Adequacy Issue:	Adequate		Inadequate		**DATA ADEQUACY WORKSHEET**	Revision No.	0	Date	
Technical Area:	**Geological Hazards**				Project:	SES Solar One	Technical Staff:		
Project Manager:					Docket:		Technical Senior:		

SITING REGULATIONS	**INFORMATION**	**AFC SECTION NUMBER**	**ADEQUATE YES OR NO**	**INFORMATION REQUIRED TO MAKE AFC CONFORM WITH REGULATIONS**
Appendix B (g) (1)	...provide a discussion of the existing site conditions, the expected direct, indirect and cumulative impacts due to the construction, operation and maintenance of the Project, the measures proposed to mitigate adverse environmental impacts of the Project, the effectiveness of the proposed measures, and any monitoring plans proposed to verify the effectiveness of the mitigation.	Section 5.3.1 Section 5.3.2 Section 5.3.3 Section 5.3.4		
Appendix B (g) (17) (A)	A summary of the geology, seismicity, and geologic resources of the Project Site and related facilities, including linear facilities.	Section 5.3.1.1 Section 5.3.1.3		
Appendix B (g) (17) (B)	A map at a scale of 1:24,000 and description of all recognized stratigraphic units, geologic structures, and geomorphic features within two (2) miles of the Project Site and along proposed facilities. Include an analysis of the likelihood of ground rupture, seismic shaking, mass wasting and slope stability, liquefaction, subsidence, tsunami runup, and expansion or collapse of soil structures at the plant site. Describe known geologic hazards along or crossing linear facilities.	Section 5.3.1.2 Figure 5.3-2 Figure 5.3-3* *Note: scale modified to 1 inch = 1 mile due to size of Project and extent of linears facilites		
Appendix B (g) (17) (C)	A map and description of geologic resources of recreational, commercial, or scientific value which may be affected by the Project. Include a discussion of the techniques used to identify and evaluate these resources.	Section 5.3.1.3 Figure 5.3-3		

Adequacy Issue:	Adequate		Inadequate		**DATA ADEQUACY WORKSHEET**	Revision No.	0	Date	

Technical Area:	**Geological Hazards**	Project:	SES Solar One	Technical Staff:	
Project Manager:		Docket:		Technical Senior:	

SITING REGULATIONS	**INFORMATION**	**AFC SECTION NUMBER**	**ADEQUATE YES OR NO**	**INFORMATION REQUIRED TO MAKE AFC CONFORM WITH REGULATIONS**
Appendix B (i) (1) (A)	Tables which identify laws, regulations, ordinances, standards, adopted local, regional, state, and federal land use plans, leases, and permits applicable to the proposed Project, and a discussion of the applicability of, and conformance with each. The table or matrix shall explicitly reference pages in the application wherein conformance, with each law or standard during both construction and operation of the facility is discussed; and	Table 5.3-3		
Appendix B (i) (1) (B)	Tables which identify each agency with jurisdiction to issue applicable permits, leases, and approvals or to enforce identified laws, regulations, standards, and adopted local, regional, state and federal land use plans, and agencies which would have permit approval or enforcement authority, but for the exclusive authority of the commission to certify sites and related facilities.	Table 5.3-3		
Appendix B (i) (2)	The name, title, phone number, address (required), and email address (if known), of an official who was contacted within each agency, and also provide the name of the official who will serve as a contact person for Commission staff.	Table 5.3-4		
Appendix B (i) (3)	A schedule indicating when permits outside the authority of the commission will be obtained and the steps the applicant has taken or plans to take to obtain such permits.	Table 5.3-5		



SOURCES: ESRI (overview);
Stantec Engineering (project site Oct. 2008);
USGS (7.5' quads various dates).

REGIONAL VICINITY MAP
SOLAR ONE PROJECT

URS

CREATED BY: LG	DATE: 11-13-08	FIG. NO:
PM: WM	PROJ. NO: 27658173.10000	5.3-1

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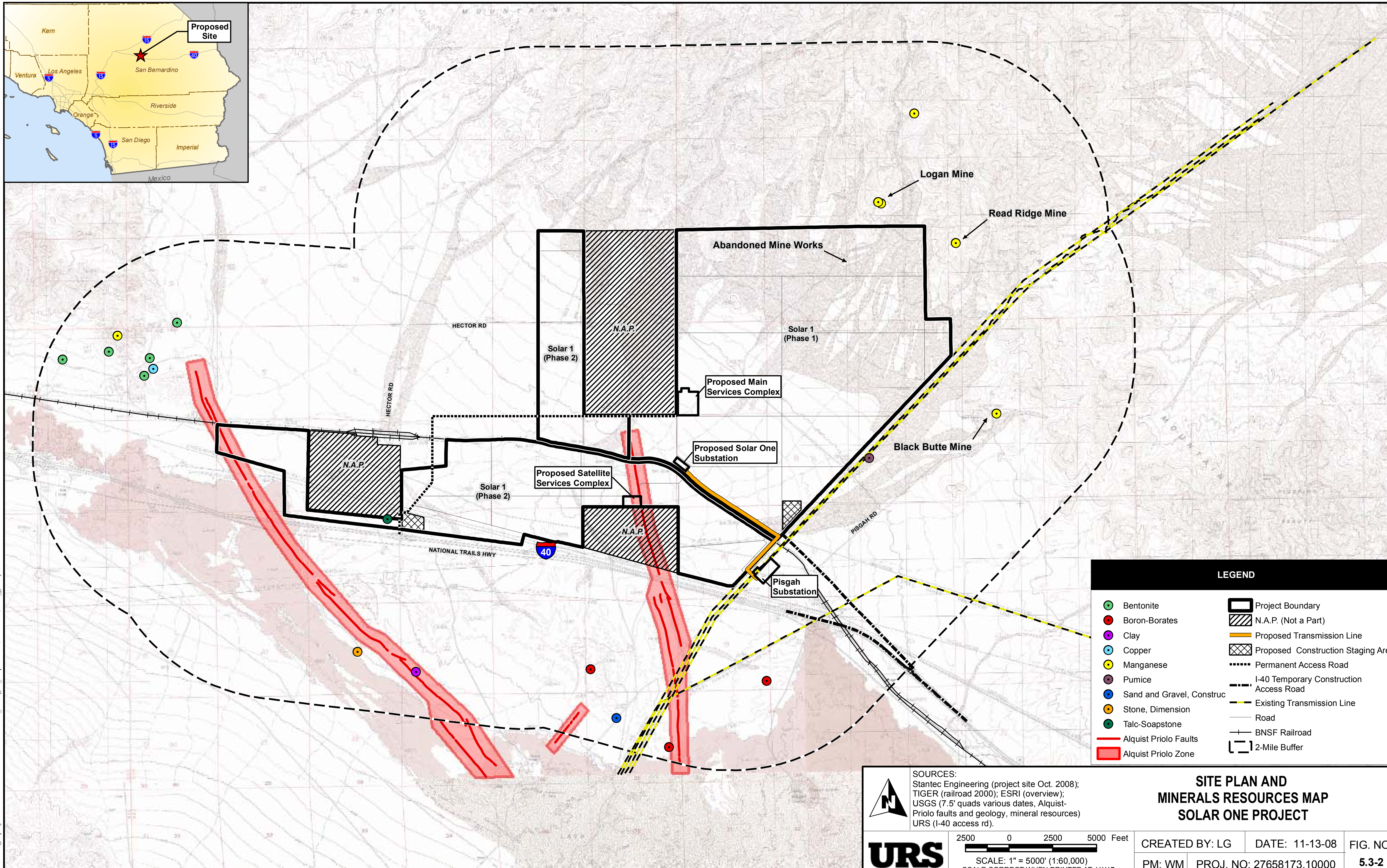

SITE PLAN AND MINERALS RESOURCES MAP SOLAR ONE PROJECT

FIG. NO: 5.3-2

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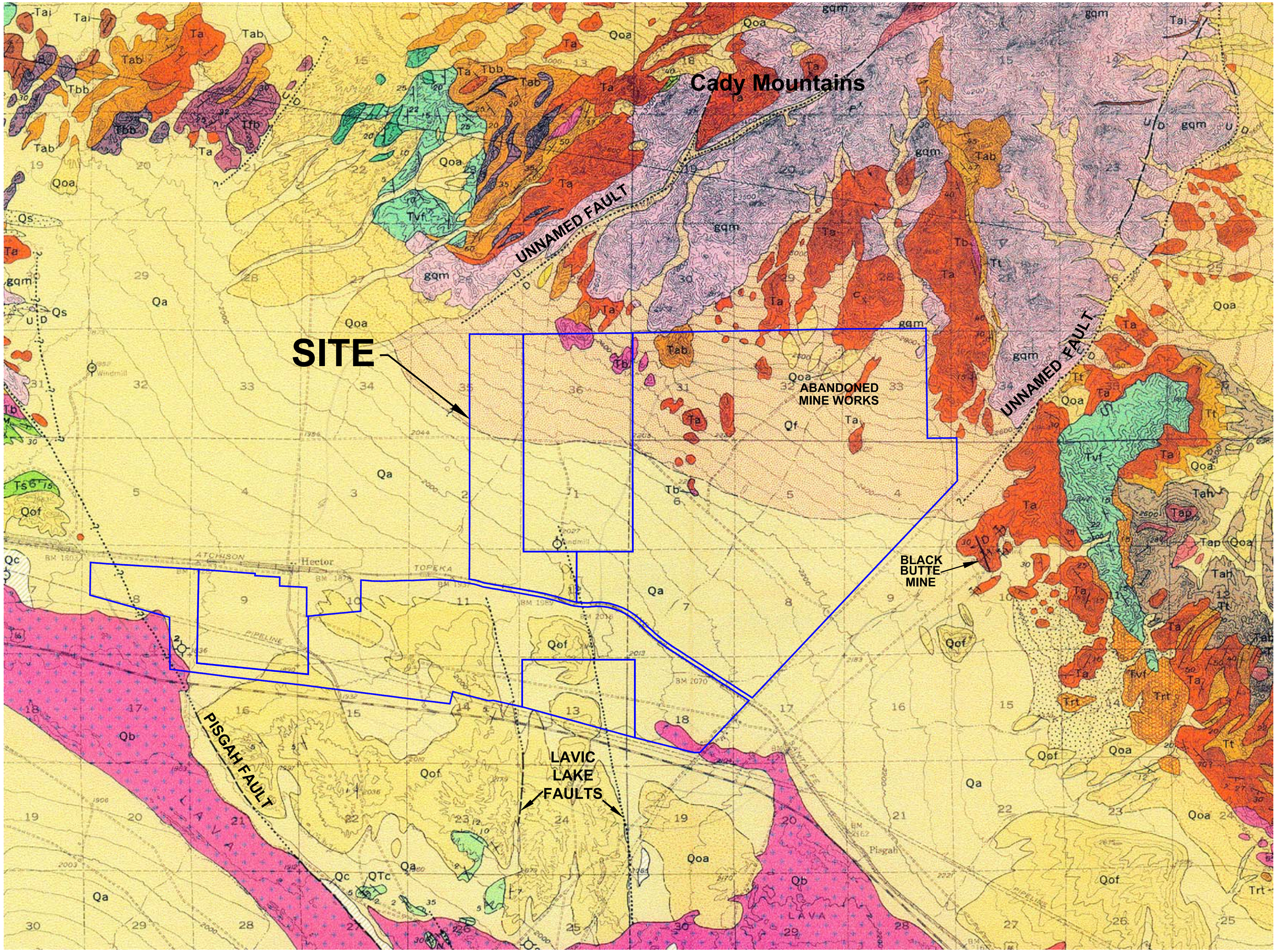
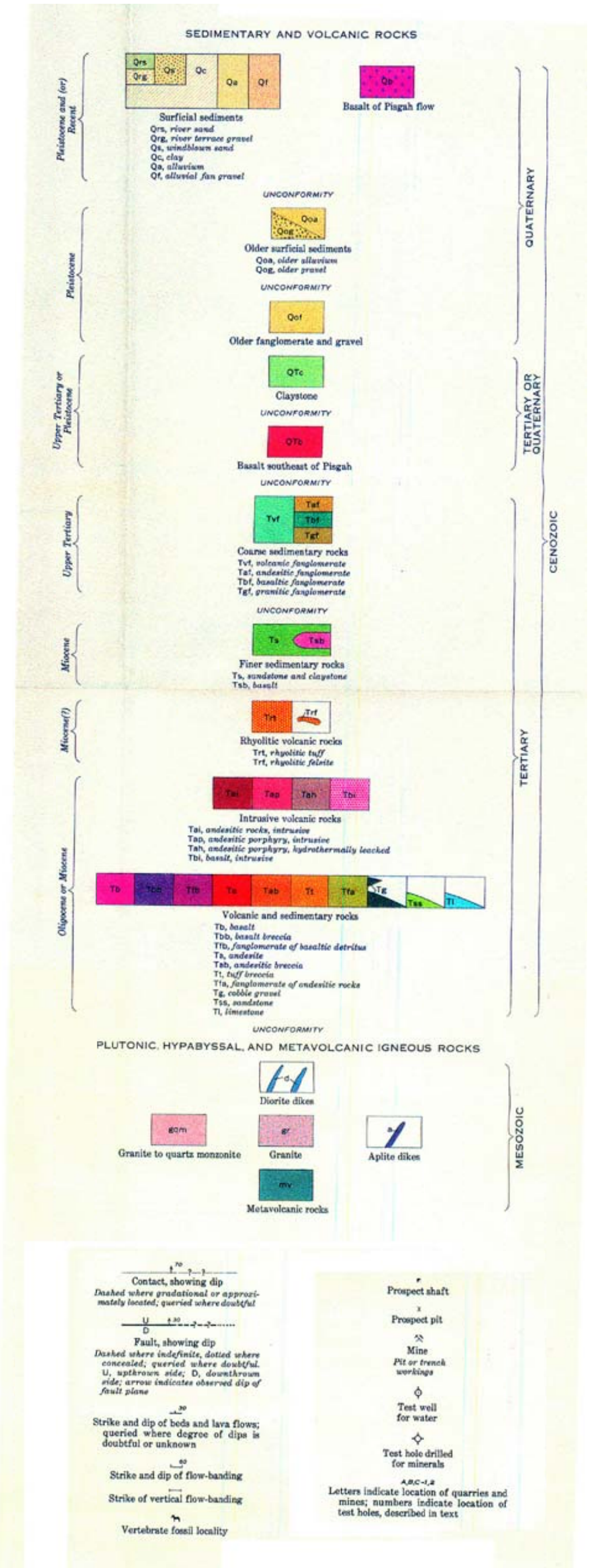


EXPLANATION



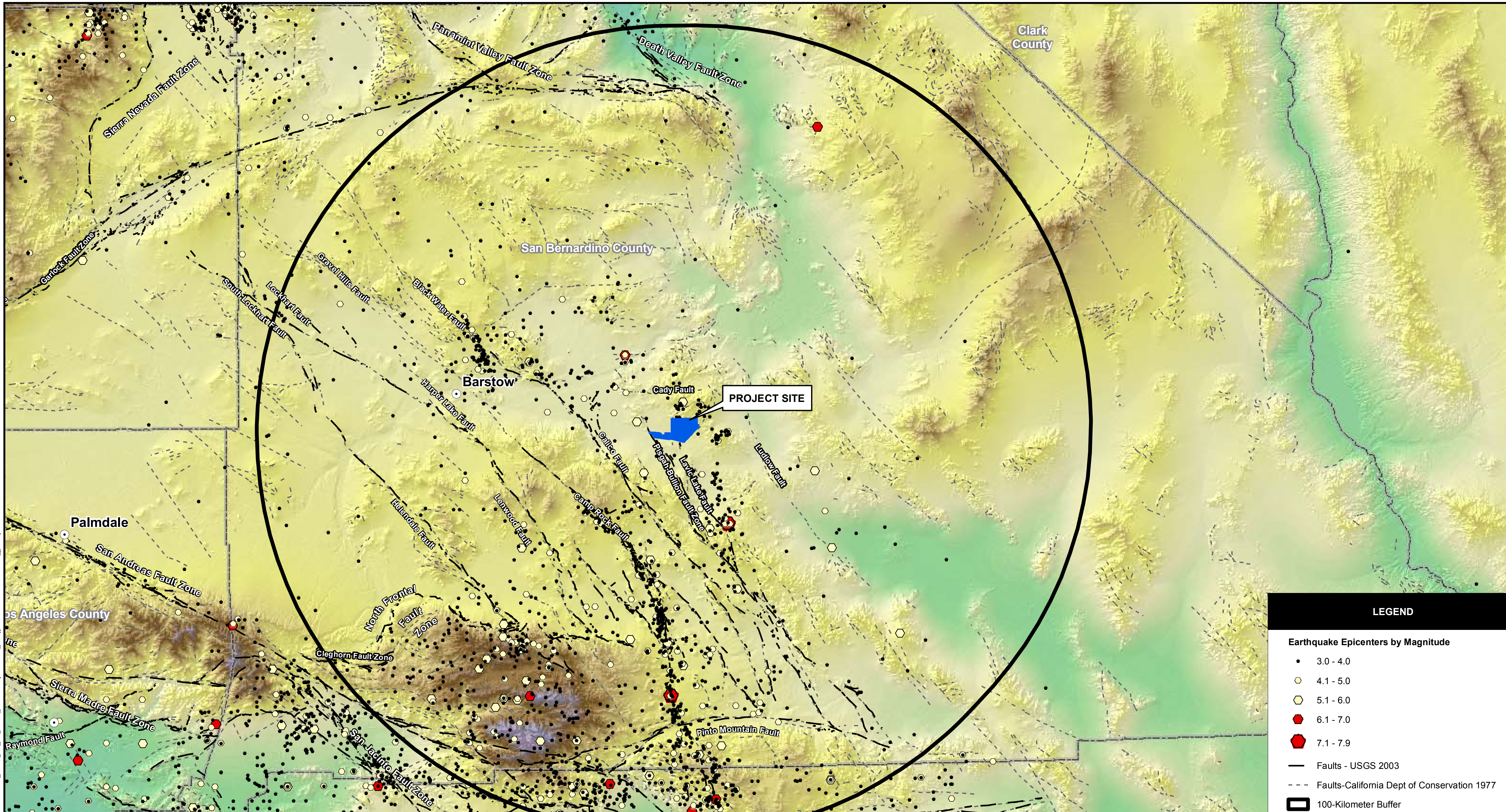
SOURCE:
Geologic Map of the Cady Mountains, San Bernardino County, California, by T.W. Dibbee, Jr., and A. M. Bassett

0.5 0 0.5 1 mile
APPROXIMATE SCALE: 1" = 1 mile

SITE GEOLOGIC MAP
SOLAR ONE PROJECT

CREATED BY: CM	DATE: 11-14-08	FIG. NO:
PM: WM	PROJ. NO: 27658173.10000	5.3-3

X:\27658105\solar one mineral resources map.dwg||Nov-14-2008:11:11



SOURCES:
Stantec Engineering (Oct. 2008);
Ca. Dept. of Conservation's Geological Survey (So. Cal. Seismic Network data catalog 2008);
USGS (Faults 2007).

REGIONAL FAULT AND HISTORICAL EPICENTERS MAP
SOLAR ONE PROJECT

URS

7.5 0 7.5 15 Miles
SCALE: 1" = 15 Miles (1:950,400)
SCALE CORRECT WHEN PRINTED AT 11X17

CREATED BY: LG	DATE: 11-17-08	FIG. NO:
PM: WM	PROJ. NO: 27658173.10000	5.3-4

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